CERTIFICATE OF MAILING BY "EXPRESS MAIL"

"Express Mail" mailing label number EV 360018302 US
Date of Deposit September 18, 2003

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Mail Stop Patent Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Karen A. Sanderson
(Typed or printed name of person mailing paper or fee)

Karen A. Sanderson
(Signature of person mailing paper or fee)

APPLICATION FOR UNITED STATES LETTERS PATENT

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that Roland Strähle
a citizen of GERMANY, residing at Greuthweg 4
D-72669 Unterensingen, GERMANY
has invented a new and useful
REINFORCED STACKED PLATE HEAT EXCHANGER
of which the following is a specification.

REINFORCED STACKED PLATE HEAT EXCHANGER

CROSS REFERENCE TO RELATED APPLICATION(S)

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

REFERENCE TO A MICROFICHE APPENDIX

Not applicable.

TECHNICAL FIELD

The present invention is directed toward heat exchangers, and particularly toward housing-less stacked plate heat exchangers.

BACKGROUND OF THE INVENTION AND TECHNICAL PROBLEMS POSED BY THE PRIOR ART

Stacked plate, or "housing-less" heat exchangers are known in the art. For example, as illustrated in DE OS 30 21 246 (which is probably intended for us in the food processing field), such heat exchangers include a stack of plates which are secured together around their edges to define closed channels between the plates. Aligned openings in the plates define passages through the plate stack for input and output of fluids, such as gaseous or liquid coolants, between which heat is to be exchanged. Seals are provided between the plates around selected openings to block selected defined passages from communication with selected plate channels, such that two separate fluid paths

may be provided, typically with the separate paths defined in alternating channels in the stack. Flow path defining elements such as serpentine fins have also been provided in the channels of some stacked plate art heat exchangers to assist in heat exchange, both by carrying heat from the space to the plates and also by assisting in spreading flow across the plates to maximize the effective heat exchange surfaces.

However, such stacked plate heat exchangers have not been readily usable in applications using fluids which are under particularly high pressures.

The present invention is directed toward overcoming one or more of the problems set forth above.

SUMMARY OF THE INVENTION

In one aspect of the present invention, a heat exchanger for exchanging heat between a first fluid and a second fluid is provided, including a plurality of stacked plates, including a cover plate on one side of the stacked plates and a base plate on the other side of the stacked plates. The plates are spaced from one another to define channels therebetween, with each of the plates except the base plate including first, second, third and fourth openings therethrough, which openings are aligned to define first, second, third and fourth passages through the stacked plates. The first and third passages are input and output passages, respectively, for the first fluid, and the second and fourth passages are input and output passages, respectively, for the second fluid. The first fluid input and output passages communicate with a first group of the defined channels, and the second fluid input and output passages communicate with a second group of the defined channels, with the channels

of the first group being alternately disposed between the channels of the second group. A reinforcing body is disposed in one of the first, second, third and fourth passages, and is secured to the cover plate and the base plate and spaced from the sides of the openings defining the one passage in the stacked plates between the cover and base plates.

In one form of this aspect of the present invention, a fluid flow path is defined between the reinforcing body and the aligned openings defining the one passage.

In another form of this aspect of the invention, the reinforcing body is a substantially cylindrical rod and the one passage is substantially round whereby fluid passes through an annular portion of the one passage around the reinforcing body.

In still another form of this aspect of the invention, the opening of the cover plate defining the one passage has a collar therearound defining a diameter smaller than the diameter of the openings of the other plates defining the one passage, the reinforcing member has a neck secured in the collar, and fluid openings extend through the collar communicating with the one passage. This form may further include a connector secured to the cover plate and adapted to connect with a fluid line whereby fluid may flow between the fluid line and the one passage through the fluid openings. Further, the reinforcing member neck may be soldered in the collar, or the collar may be an integrally formed deformation of the cover plate, or the collar may be a ring fixed to the cover plate. Still further, a fluid flow path may be defined between the reinforcing body and the aligned openings defining the one passage, with the fluid flow path having a cross-sectional area substantially the same as the total cross-sectional area of the collar fluid openings. Additionally, the base plate

may include a flange with the reinforcing member soldered to the base plate flange with this form, and the flange may be an integrally formed deformation of the base plate.

In yet another form of this aspect of the invention, the first and second fluids are different, with the first fluid being CO_2 for vehicle air conditioner refrigerant and the second fluid being engine coolant in a still further form.

In yet another form of this aspect of the present invention, the plates have a generally flat heat exchange surface generally surrounded by a beveled edge, and the plates are stacked by nesting the plates with the beveled edges together and the flat heat exchange surfaces spaced. In a further form, wherein the beveled edges of nested plates are soldered together.

In still another form of this aspect of the invention, first spacing rings are provided around the first and third passages blocking communication of the first fluid input and output passages with the second group of defined channels, and second spacing rings are provided around the second and fourth passages blocking communication of the second fluid input and output passages with the first group of defined channels. In a further form, the first spacing rings are secured in the space between the plates defining the second group of defined channels.

In yet another form, alternating plates between the cover plate and the base plate have a thickness generally corresponding to the thickness of the cover and base plates, and the plates between the alternating plates have a thickness less than the cover and base plate thickness.

In another aspect of the present invention, a heat exchanger such as described with the first aspect of the invention is provided, further including

a second reinforcing body disposed in the third passage, with the second reinforcing body being secured to the cover plate and the base plate and spaced from the sides of the openings defining the third passage in the stacked plates between the cover and base plates.

In one form of this aspect of the invention, the plates are generally rectangular, and the first and third passages are disposed adjacent opposite corners of the plates.

In another form of this aspect of the invention, the first fluid is CO_2 for vehicle air conditioner refrigerant and the second fluid is engine coolant.

In yet another form of this aspect of the invention, third and fourth reinforcing bodies are provided in the second and fourth passages, respectively, where the third reinforcing body is secured to the cover plate and the base plate and spaced from the sides of the openings defining the second passage in the stacked plates between the cover and base plates, and the fourth reinforcing body is secured to the cover plate and the base plate and spaced from the sides of the openings defining the fourth passage in the stacked plates between the cover and base plates.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an exploded view of a stacked plate heat exchanger embodying the present invention;

Figure 2 is a cross-sectional view taken diagonally through a stacked plate heat exchanger such as illustrated in Fig. 1, with the cross-sectional plane through the two connectors being different for illustrative purposes.

DETAILED DESCRIPTION OF THE INVENTION

A stacked plate heat exchanger 10 embodying the present invention is illustrated in Figs. 1-2.

The heat exchanger 10 consists of a plurality of generally rectangular plates 14, 16, including top and bottom plates 14a, 14b. The plates 14, 14a, 14b, 16 include a generally flat portion 20 surrounded by beveled edges 22, and are stacked or nested together with a space between adjacent plate flat portions 20 as described further below. In this manner, alternating flow channels 24, 26 are defined between the plates, with a first group of flow channels 24 being every second channel (*i.e.*, those located in the space above the flat portion 20 of each plate 16 and below the flat portion 20 of the adjacent plate 14) and a second group of flow channels 26 being the alternating every second channels defined in the space above the flat portion 20 of each plate14 and below the flat portion 20 of the adjacent plates 16, 14a.

The plates 14, 14a, 14b, 16 may consist of aluminum sheets coated with solder, with their size and shape chosen according to the intended use. In the illustrated embodiment, plates 14, 14a, 14b are relatively thicker than plates 16.

Traversable plates such as serpentine fins 28 (see Fig. 2, which illustrates some but not all such fins 28) may be inserted between plates 14, 14b, 16 in the flow channels 26 in a suitable manner, with the crests suitably secured to the plates as by soldering. The fins 28 provide greater pressure resistance for the heat exchanger, and additionally assist in heat exchange as well as assisting in guiding and spreading the flow of fluid through the flow channels 26.

In the illustrated embodiment, plates 14, 14a, 16 each include a generally circular opening 30, 32, 34, 36 adjacent each corner. Since the fluid inputs and outputs are through the top plate 14a, openings are not provided through the bottom plate 14b. However, it should be understood that in alternate embodiments, two openings could be provided in each of the top and bottom plates, for example, where the system environment would advantageously accommodate two of the inputs and outputs on one side and the other two on the other side. Similarly, three openings could be provided in one of the top and bottom plates and one in the other of the top and bottom plates within the scope of the present invention.

The aligned openings 30, 32, 34, 36 of the plates define passages 40, 42, 44, 46 extending through all but the bottom plate 14b of the heat exchanger 10. Suitable connectors 50a, 50b, 52a, 52b (described in greater detail hereafter) are provided to connect to the source of fluids between which heat is being exchanged. While heat exchangers embodying the present invention could be advantageously used in applications in which heat is exchanged between any two selected gaseous or liquid fluids, the illustrated heat exchanger 10 is contemplated for use with a vehicle, with the fluids being engine coolant and CO_2 used as a vehicle air conditioner refrigerant. It will be appreciated by those skilled in this art that since the CO_2 is at such high pressure, the spacing between the plates 14, 16 defining the first group of flow channels 24 is significantly less than the spacing defining the second group of flow channels 26 (through which liquid engine coolant flows).

Thus, as indicated by the arrows 56 (and as explained in greater detail below), CO_2 flows from inlet connector 50a, to passage 44, to the various channels 24, to passage 40, and out connector 50b. Similarly, as indicated by

the arrows 58, the engine coolant flows from inlet connector 52a, to passage 46, to the various channels 24, to passage 42, and out connector 52b. It will be appreciated that, with heat exchangers of this type, suitable spacing elements may be provided around selected ones of the aligned openings so as to either to block a passage from a channel (where such flow is not desired) or to provide an open gap from a passage to a channel (where such flow is desired) (*e.g.*, by providing such spacers only at the other passages at that channel).

For example, as best illustrated in Fig. 2, flanges forming upwardly extending collars 60 of the thicker plates 14 are provided around the openings 30, 34 defining the passages 40, 44 for the CO_2. Those collars 60 are sealingly secured to the plates 16 above them, thereby blocking flow of CO_2 into the second group of channels 26. Since no such collars are provided around the other openings 32, 36 of the thicker plates 14 (see Fig. 1), it will be appreciated that there will be a gap between the plates 14, 16 at those other openings 32, 36, whereby engine coolant will be able to flow between the passages 42, 46 and the second group of channels 26. A similar arrangement is provided above the plates 16, whereby engine coolant in the passages 42, 46 is blocked from the channels 24 defined there, whereas a gap (albeit significantly smaller than with channels 26) around the passages 40, 44 allows flow of CO_2 between the passages 40, 44 and the first group of channels 24.

It should be appreciated that flow according to arrows 56, 58 is merely one arrangement which may be used, and that other cross-current or counter-current arrangements could also be used.

In accordance with the present invention, a reinforcing body 70 may be provided in at least one of the passages 40, 42, 44, 46, including

providing such bodies in all of the passages 40, 42, 44, 46. In the illustrated embodiment, two such bodies 70 are provided, in the passages 40, 44 through which the high pressure CO_2 flows.

The reinforcing bodies 70 are generally similar in cross-sectional shape to the shape of the passages 40, 44, though somewhat smaller in size. With circular openings 30, 34 and cylindrical reinforcing bodies 70, therefore, a generally ring-shaped or annular passage having an inner diameter "di" and an outer diameter "da" is defined for flow of the CO_2. Such an annular passage configuration may contribute to excellent distribution of the fluid (*e.g.*, CO_2 refrigerant) to all the flow channels 24 so that a very good heat exchange rate is achieved when a large number of flow channels 24 formed from the heat exchanger plates 14, 16 are provided. The annular flow path passes through the entire plate stack and therefore distributes the CO_2 to those flow channels 24. However, it should be recognized that the flow path need not be formed with the same dimensions, or annularly, over the entire plate stack (*i.e.*, the cross section of the bodies 70 that determine the flow path need not be designed to be uniform over the entire stack).

Moreover, the reinforcing bodies 70 may be tapered on their ends to reduced neck portions 72, 74 on opposite ends, which neck portions 72, 74 are suitably secured (as by soldering) into collars 76, 78 defining a reduced diameter around the openings 30, 34 in the cover plate 14a and base plate 14b. The collars 76, 78 may be formed in any suitable manner, as by deformation of the plates 14a, 14b. A direct connection between the neck portions 72, 74 of the bodies 70 and the base plate 14b or cover plate 14a can be provided, for example, by soldering the neck portions 72, 74 directly into or onto the collars 76, 78 of the base plate 14b or cover plate 14a. The

connection may also be made indirectly within the scope of the invention, however, with an intermediate element such as a sleeve or other similar individual part used.

It should thus be appreciated that the bodies 70 will serve to provide a strong reinforcement of the stacked plates 14, 14a, 14b, 16, assisting in holding the plates together notwithstanding the potentially high pressures between the plates (*e.g.*, the high pressure of the CO_2 in the first group of channels 24). For example, with the illustrated soldered structure heat exchanger 10 constructed from aluminum sheet coated with solder and the body extends essentially through the entire distribution or collection channel, extremely good pressure stability is provided such as is particularly suitable for heat exchange between the refrigerant (*e.g.*, CO_2) of an air conditioner and the engine coolant of the vehicle. Such refrigerant is known to be under a very high pressure of up to about 150 bar operating pressure, requiring such heat exchanger to withstand a maximum pressure of about 450 bar without losing their function. Moreover, this pressure stability can be provided without the use of larger sheet thicknesses which present their own cost and weight drawbacks (weight being a particularly important factor in vehicular applications).

In order to provide fluid (*e.g.*, CO_2) flow between the connectors 50a, 50b and the annular passages 40, 44, suitable fluid openings 80 may be provided through a flange portion 82 around the collar 76 in the cover plate 14a. The flange portion 82 may be used to assist in properly securing the connectors 50a, 50b to the cover plate 14a (*e.g.*, by metallic bonding such as soldering) to ensure such desired flow. Specifically, as best shown in the cross-sectional view of connector 50a on the right of Fig. 2, the connectors 50a, 50b may have lateral slots 88 which are aligned with the fluid openings 80

whereby fluid (*e.g.*, CO_2) may flow through the slots 88 and fluid openings 80 (as shown by arrows 90) and around the securement of the reinforcing bodies 70 and collars 76 on the cover plate 14a.

In should be appreciated that the above described connection between the cover plate 14a and the reinforcing bodies 70 is merely illustrative, and that any such connection which will provide the described reinforcement as well as allow the desired fluid flow could also advantageously be used in connection with the present invention. However, the illustrated design is particularly advantageous since it ensures that the fluid flow can be produced more easily in terms of design and manufacture. Nevertheless, it should be appreciated that by providing the described flow paths around the reinforcing bodies 70, it is possible to offer significant design freedom, without significantly enlarging the entire cross-sectional surface (which could detrimentally affect pressure forces acting in the plate heat exchanger). Further, the reinforcing bodies 70, openings 30, 34 defining passages 40, 44, fluid openings 80, and connectors 50a, 50b may be advantageously sized so that the defined annular passages (which may have a small radial dimension of, *e.g.*, only 6 mm) around the reinforcing bodies 70 correspond roughly to the cross-sectional surface of the fluid openings 80 and connector lateral slots 88 in order to create favorable flow conditions.

Still other aspects, objects, and advantages of the present invention can be obtained from a study of the specification, the drawings, and the appended claims. It should be understood, however, that the present invention could be used in alternate forms where less than all of the objects and advantages of the present invention and preferred embodiment as described above would be obtained.